MAINTENANCE MANUAL

FOR

MODEL 650B

FIBER OPTIC LEVEL MEASURING TEST SET

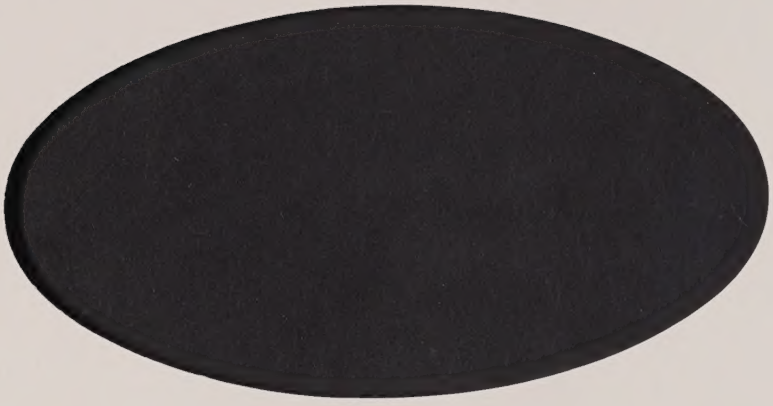
AND 651B PLUG-IN

Bowmar

WHEN QUALITY COUNTS

Communications Test Equipment

Bowmar/ALI Inc.
531 Main Street
Acton, Mass. 01720



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AND 651B PLUG-IN

Manufactured By:

BOWMAR/ALI, INC.
531 Main Street
Acton, Massachusetts 01720

Revision 2
February, 1983

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Bowmar/ALI, Incorporated

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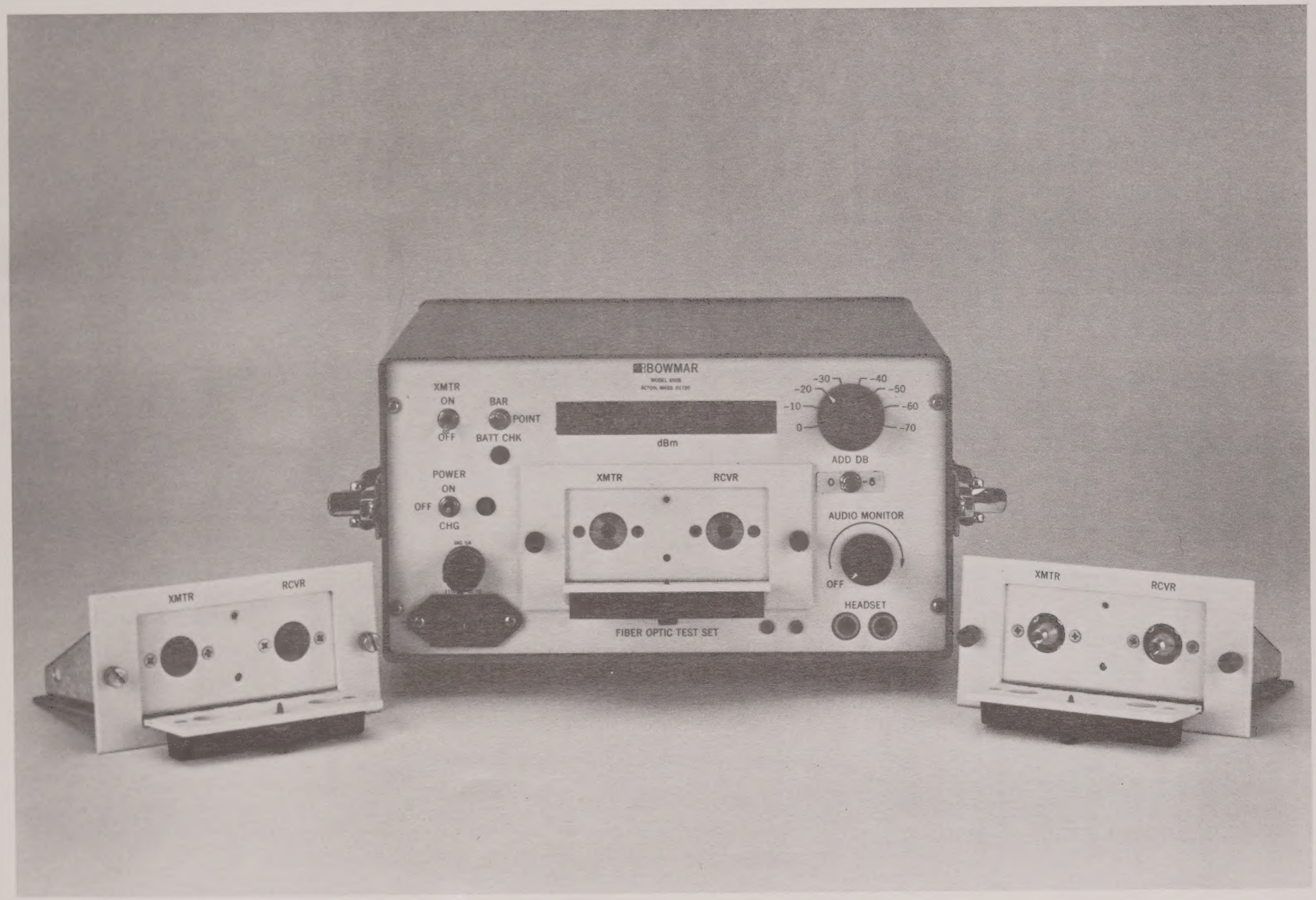
BOWMAR
XMTR
ON
OFF
BAR
POINT
BATT CHK
dBm
-30
-40
-20
-50
-10
-60
0
-70
ADD DB
0
6
POWER
ON
OFF
CHG
XMTR
RCVR
AUDIO MONITOR
OFF
HEADSET
FIBER OPTIC TEST SET
XMTR
RCVR
XMTR
RCVR

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STORAGE

The only concern when storing the Model 650B Test Set or the Model 651B Plug-Ins is the sealed lead batteries in the Model 650B. These batteries should be fully charged when placed in storage. The batteries are charged by applying AC power to the Model 650B and placing the POWER Switch in the CHG position. The Test Set should be left on charge for 16 hours to fully charge the batteries. Battery charge can be checked by removing AC power from the Test Set and depressing the BAR/POINT/BATT CHK Switch to the BATT CHK position. The BATT CHK LED will light if the battery is charged. The 650B Test Set is shipped with the batteries fully charged.

Batteries stored at temperatures less than +80°F should be recharged every one year. Batteries stored between +80° and +122°F should be recharged every 6 months. Batteries should not be stored above +122°F (+50°C).

If long term storage is anticipated, it may be preferable to remove the batteries from the 650B Test Set. Instructions on battery removal are included in Section 5.2 of this Maintenance Manual.

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1.0 INTRODUCTION

1.1 Scope

This manual presents instrument specifications, theory of operation, calibration and maintenance information as well as diagrams and schematics in a manner that allows ready reference for the maintenance of the Bowmar Model 650B Fiber Optic Test Sets and Model 651B Plug-In Modules.

1.2 Description

The Bowmar Model 650B Fiber Optic Level Measurement Test Set is a portable and rugged instrument which allows fast and accurate testing of fiber optic cables in the field, central office or laboratory. The test instrument has a transmitter and a receiver and is used for making absolute or relative light level measurements. Light level in dBm is indicated on the solid state, Analog Panel Meter. The Model 650B's modular construction features a plug-in (designated Model 651B) which contains the fiber optic cable connectors, the LED source, and the detector. A variety of interchangeable plug-ins are available. The 650B has rechargeable batteries and a built-in battery charger. A low battery indicator provides a warning when battery charging is required. The transmitter ON/OFF switch serves to conserve battery power when making receive level measurements on a simplex end-to-end test.

The Bowmar connectors permit rapid, accurate, and repeatable measurements of connectorless fiber cables. This unique Bowmar proprietary design eliminates the need for making costly and time-consuming terminations.

The audio monitor gives a new dimension to fiber splicing. This feature aids in attaining the lowest loss level in splice alignment and can be used locally or remotely.

Bowmar's Model 650B is an easy-to-use, accurate, rugged, and indispensable tool for anyone engaged in fiber optic systems technology.

1.3 Specifications

Transmitter	651B-_	651B-_B	651B-_A
Level	-20 dBm	-20 dBm	-20 dBm
Frequency	DC	DC	DC
Source	LED (810-830 nm)	LED (840-860 nm)	LED (1265-1320 nm)
Receiver	**651B-_, 651B-_B**		**651B-_A**
Detector	PIN Photodiode (Si)		PIN Photodiode (GE
Range	+2 to -80 dBm		+2 to -60 dBm
Wavelength	720 nm to 880 nm	550 nm to 940 nm	600 nm to 2000 nm
Accuracy (25°C)	± 0.5 dB	+0.5/-3.0 dB	± 0.5 dB (1290 nm)*

*Background signal level is -58 dBm maximum over +5° to +35°C temperature range

Record Output	0 to 1 VDC. Do not load with less than 1000 ohms.
Temperature	
Operating	0° to +40°C; +5°C to +35°C (1300 nm)
Storage	-40°C to +70°C
Power	
AC Power	115 ± 15% VAC 47 to 63 Hz (Optional: Factory wired for 230V ± 15%, 47 to 63 Hz.) Maximum draw of 12 watts.
Battery Life	8 hours with transmitter on, and the display in the bar mode (nominal 1/2 bar). 12 hours with transmitter on, and the display in the single point mode. (3) 6V sealed lead-acid batteries rechargeable with built-in charger. Battery recharge cycle is 16 hours. (Gates Part No. 0810-0011A)

Audio Monitor

A +2 dB meter reading (full scale) corresponds to a 2 KHz audible tone when the volume switch is ON. The frequency of the tone is dependent upon the meter reading, signal frequency decreasing as the meter reading decreases. The frequency range is from 100 Hz through 3 KHz.

Jacks are included to mate with WE-289B twin-plug. When a twin headset plug is connected, the internal speaker is disabled. The signal output level is -30 to -43 dBv into 300 ohms or greater controlled by the Audio Monitor Volume Control.

Dimensions	10-1/2" W x 5-3/4"H x 11"D.
Weight	15 lbs.
Connectors	
Bowmar	Unterminated cable adapter for a wide variety of 125 micron fibers. Other sizes and connectors (AMP, Amphenol, ITT, etc.) available upon request.

2.0 INSTALLATION AND OPERATIONAL CHECK

2.1 Inspection

While the Fiber Optic Test Set is thoroughly tested and inspected prior to shipment, the possibility of damage in transit should not be overlooked. Carefully examine the instrument for indications of mechanical damage and for the presence of all specified accessories.

2.2 Power Requirements

AC

The Test Set will normally be wired for 115 VAC operation. For applications where 230 VAC is required, the unit can be factory wired for this option.

Battery

This Test Set comes equipped with three (3) 6V sealed lead-acid rechargeable batteries. These batteries are wired in series for 18V DC nominal. A battery charger is built into the Test Set, and a test circuit is supplied to monitor the charge of the batteries.

2.3 Operational Check

With the XMTR ON/OFF switch in the OFF position and the AC cord disconnected, turn the Power switch ON and depress the BATTERY CHK switch to check the batteries. The red LED will light if the batteries are charged.

To check the operation of the receiver and meter circuitry, expose the RCVR port to ambient light and turn the ADD dB switch to get an on-scale meter reading.

To check the operation of the XMTR LED and the set's zero calibration, connect a short loop fiber approximately 20 meters (on a reel or coiled) between the XMTR and RCVR ports. If a short fiber loop is used (less than 20 meters) then the loop may need to be mode stripped. With the loop cable connected between the XMTR and RCVR ports, turn on the XMTR switch and the meter should provide an "on scale" reading in either the -20 or -30 ADD dB position. R18 (or R9 depending on which plug-in model), accessible through hole in front of plug-in, may be adjusted to vary the transmitter LED's output power. Thus an initial zero may be set before using the unit to measure an unknown attenuation.

3.0 OPERATION

3.1 Front Panel Controls and Indicators

POWER ON/OFF/CHG (Power Switch)	A center off switch that controls the power to the instrument. In the up position (ON), the unit runs on either AC line or battery power. In the center position (OFF), the 650B is off. With the switch in the down position (CHG), the power is off, and with the AC cord plugged in, the instrument will charge the batteries. The LED indicator light adjacent to the power switch is activated when the power switch is in the ON position.
XMTR ON/OFF (Transmitter On/Off)	This switch is used to turn the transmitter on or off.
BAR/POINT/BATT CHK Switch	This is a 3-position switch with a momentary position for the Battery CHK. In the up (BAR) position, the meter indicator is in a bargraph mode. When in the center (POINT) position, the meter indicator is in the single point mode. The momentary down position activates the LED light indicating the battery charge. If the LED fails to light, the batteries need to be recharged. (Battery check should be done without the AC cord connected.)
ADD dB Switch	This is an 8-position rotary switch which increases or decreases the receiver gain in 10 dB steps. This indicated value must be added to the meter reading to establish absolute light level in dBm.
0 -5 Switch*	Adds 5 dB to received level.
AUDIO MONITOR	An ON/OFF volume control knob is provided to control an audio tone. When the audio monitor is on, the 650B display is automatically locked into the point mode on the meter.

*Not present on some early models.

Headset	Jacks (Switchcraft MT332A 5/8" on centers) are provided for standard interface to a headset or VF pair. The internal audio monitor speaker is bypassed when the jacks are in use and the audio signal is applied between the rings of the appropriate plugs.
Unlabeled Jacks (Record Output)	Sealectro test jacks (fit pin size .080") are located in the lower center side of the panel. The output is 0 to 1 VDC (Do not load with less than 1000 ohms). The DC voltage appearing at these jacks (Red-Signal, Black-Ground) can be converted to a dB level using the following formula: Level (dB) = -10 Log (.63/VDC)

3.2 Bowmar Connectors

A proprietary design for use with unterminated fibers with diameters of 125 microns. Other sizes available upon request.

Unterminated fiber can be prepared, the Bowmar connector applied, and the fiber tested in a few minutes. These connectors allow fast, accurate, and repeatable measurements using unterminated fibers. In a matter of minutes measurements can be made with a repeatability of approximately $\pm$ 0.2 dB. Refer to the Bowmar 650B Operations Manual, Section 4, for additional information on the use of the Bowmar connector as well as general applications information on the 650B.

4.0 THEORY OF OPERATION

4.1 General

Refer to Block Diagram (Figure 1) and circuit description to follow.

4.1.1 Transmitter

The LED output is continuous and is driven from a constant current source. Wavelength of 810 - 830, 840 - 860 or 1265 - 1320 depending on which plug-in model.

4.1.2 Receiver

The detector used is a PIN photodiode calibrated at the standard wavelength.

The output of the detector is amplified and fed to the dB meter and a buffer amplifier which is used to drive the record jacks and the audio jacks.

4.1.3 Power Supply

The 650B is powered either by its own self-contained battery pack or by standard 115 VAC through the front panel. The output voltage of the battery pack is regulated to provide a constant circuit voltage. The actual battery voltage is monitored by the battery low indicator circuit.

4.2 Transmitter Circuit

Refer to schematic Figure 4 and assembly drawings Figures 2 & 3. DC supply voltage VDD is applied to VR1, a +5 volt DC regulator. R18 and R19 (R9 and R8 on Long Wavelength Plug-In, refer to Figures 5 and 6) are across the output of VR1 providing an adjustable current source for the transmit LED DS1. The light output level from DS1 is very stable with temperature and other conditions. CR1 is simply a protection diode.

4.3 Receiver Circuit - Plug-In #651B-_, #651B-_B

Light is received by photodiode DR1. Amplifier U1 is configured in the transimpedance mode. R1 - R8 provide the appropriate gain while R9 - R16 provide proper bias currents to null the no signal output of U1 over temperature. C2 provides enough frequency compensation to prevent spurious oscillations from occurring at the output of U1. R20 is used to null U1's offset voltage. Since U1 is biased by VDD/2 at its + input by U3, the output of U1 rises above VDD/2 for increasing light input.

4.3.1

The signal voltage is then fed into U7 for additional amplification. U7 is configured in the standard differential amplifier mode. VDD/2 is subtracted from the signal at TP2 and amplified by R11/R9 = 32.9. R13 and R34 provide the appropriate offset null for U7.

R14 and C8 form a low pass filter. The received signal is then fed through a voltage divider formed by R17 and R33 to provide the appropriate signal for M1 from TP6. TP6 is also connected to buffer amplifier U9 which provides unity gain and drive capability for both the audio circuitry and the record output jacks J3 and J4. R37 and R39 provide 5 dB attenuation with S6 in the 0 position.*

*5 dB switch not present on some early models.

4.3.1 Receiver Circuit - Long Wavelength Plug-In #651B-_A Only

This receiver circuit is designed to measure long wavelenths (1300 nm). Light is received by photodiode DR1. Amplifier U2 is configured in the transimpedance mode. R11 - R16 provide the appropriate gain. IC U1 along with R5 is used to null the offset voltage of U2. C6 provides enought frequency compensation to prevent spurious oscillations of U2. U2 is biased by VDD/2 at its + input, the output of U2 rises above VDD/2 for increasing light input. The remaining circuitry (from U7 on) is the same as described in 4.3.1.

4.4 Power Supply Circuit

Switch S2A provides AC power to transformer T1. CR3 is a full-wave bridge rectifier. C4 controls the amount of ripple from CR3. U6 is an adjustable voltage regulator configured using Q2 as an external pass transistor. R22 limits the output current to approximately 650 mA. CR4 is a 16* volt zener which protects U6 from over voltage. The output voltage from this stage is controlled by R24. This circuit charges the battery pack.

The battery packs' output voltage is monitored by U5. When the battery voltage is above a 17.6 VDC threshold (set by resistor divider input at U5-3) and S5 is in the BATTERY CHECK position, current is drawn through DS3. When the battery voltage falls below threshold, DS3 is OFF. R21 serves to limit the current through DS3.

With S2B in the ON position, the battery voltage is regulated by U4 to provide a constant circuit voltage, VDD. U4 is used in the same configuration as U6 except that R25 is provided for stability over temperature. Q1 is an external pass transistor; R15 limits the output current to about 650 mA and R28 is used to adjust VDD.

The resistor divider formed by R7 and R8 supplies VDD/2 to U3 which is configured as a voltage follower.

VR2 is a three terminal voltage regulator which provides a +5 VDC to power M1.

4.5 Audio Monitor Circuit

A2-U1 is configured as a voltage to frequency converter which accepts a 0-1 VDC signal at E1 and converts this to an audio frequency in a linear manner (1.0 VDC $\Longrightarrow$ 2 KHz, 0.1 VDC $\Longrightarrow$ 200 Hz) at TP1. R1, R2 and R16 provide a maximum of 10 uA input to U1-3 and with C3 determine the output frequency. R3 and R4 provide an offset for U1's internal op-amp. R5 and R6 are pull up resistors for open collector outputs at U1-8 and U1-10. A frequency twice that at TP-1 should be present at U1-8.

The signal at TP-1 is then attenuated through the VOLUME potentiometer and fed to U2. U2 is a simple power amplifier which drives the 1 watt speaker from E9. When headphone jacks are inserted, the output from E9 is disconnected and R13/R14 divide the signal further. E5 then provides signal power to the headphone jacks.

*10 volts on some early models.

4.6 Analog Meter

The analog meter has 6 studs for connections. They are labeled as indicated in schematic Figure 4. R38 connected between BC and +VS controls the brightness of the meter's LEDs. Increasing R38 will reduce the brightness but it will also increase the time between battery recharges. Decreasing R38 will have the opposite effect.

The BAR stud on the meter controls whether the meter displays a single point, or a full bar. The FB/SP signal from S5 and the power ON signal from the audio monitor are gated by A1-U8 to produce the appropriate logic level at the BAR stud. A logical "low" will produce the full bar display. Notice that, if the audio monitor is ON, the meter must display the single point only. Display of the full bar and, to a lesser extent, use of the audio monitor has a large effect on the time between charging for the battery pack. Operating lifetime between charges can be extended significantly by use of the SP mode.

5.0 CALIBRATION AND MAINTENANCE

5.1 Test Equipment Requirements

a) DMM — Data Precision 2480R or equivalent

b) Extender Board* — Bowmar 650B-215

c) DCV Supply — (0 to 20 VDC)

d) Frequency Counter

e) Radiometer (NBS Traceable)* — EG&G 450-1 or equivalent (Plug-in #651B-_, #651B-_B
Anritsu ML93A or equiv. (Long Wavelength Plug-in #651B-_A)

5.2 Calibration Procedure

Initial calibration is performed with the unit out of its case. Simply remove the two screws in the bottom of the case and the four screws in the corners of the front panel. Carefully slide the unit out of the case. The plate holding the batteries may be removed by removing four additional screws.

5.2.1 Power Supply

Disconnect the battery pack, apply AC power and turn the ON/OFF/CHG switch to the CHG position. There should be 22.0 VDC ± .1 VDC from TP5 to GND (E21). Otherwise, R24 should be adjusted for proper voltage at TP5.

Disconnect the AC power and reconnect the batteries. Check TP4 for the units' working voltage of 14.0 VDC ± .01 VDC. This voltage is adjusted by R28. Before any adjustment to R28, make sure that the battery voltage is at least 17.6 VDC. If not, apply AC power and charge the batteries. If the voltage at TP5 is less than 17.6 VDC with AC power ON, the battery pack may have degraded beyond its useable life.

5.2.2 Low Battery Threshold

R37 is set for 17.6 VDC ± .1 VDC threshold to U5 so that a decrease in battery voltage beyond that level will cause DS3 to no longer light when S5 is depressed. A variable DC supply connected from TP5 to GND instead of the battery pack may be used to adjust the BATT CHK circuit for a 17.6 VDC threshold. Remember to disconnect the AC power to the unit if this is done.

The batteries are sealed lead-acid cells with a 2.5 A-hr capacity. Care must be taken not to short any of the cells. The batteries should be good for hundreds of cycles if care is taken to insure that the unit is recharged when the output voltage drops below 17.6 VDC. Excessive over-use beyond the 17.6 VDC threshold will shorten battery life and limit the number of times the cells may be recharged.

*NOTE - The receiver should maintain it's calibration for an extended period of time. The extender board and radiometer are only necessary if the receiver needs repair or if the voltage between TP2 and TP3 with the ADD DB switch set to "0" and the RCV port blocked off exceeds 0.5 mv.

5.2.3 Receive Level Adjustment - 650B Chassis

The test set receiver is divided into two sections. The Model 651B plug-in has two adjustments, which will be discussed, and the Model 650B main chassis has one adjustment, R34. To properly set R34, remove the plug-in 651B and apply a floating power supply connected between TP2 (+) and TP3 (-) of the main P.C. board. Set the power supply output to 0.100 VDC and adjust R34 to obtain a 3.92 VDC ± .005 VDC between TP1 and GND.

5.2.4 Receive Level and LED Output Adjustments - 651B-_, 651B-_B Plug-In (820, 850 nm)

R17 and R20 on the 651B-_, 651B-_B plug-in modules should be adjusted using an appropriate extender card.* R20 is accessible through a small hole in the right-hand side of the plug-in while R17 is accessible from the left-hand side. Block off the RCV port so that no light is incident on the photodetector. Set the ADD DB switch to "0". Connect a DMM (floating) between TP2 and TP3. Adjust R20 for a 0.00 mV ± .01 mV reading.

5.2.4.1 Receive Level and LED Output Adjustments - Long Wavelength Plug-In #651B-_A (1300 nm)

R10 and R5 on the 651B-_A module should be adjusted using an appropriate extender card.* R5 is accessible through a small hole in the right-hand side of the plug-in while R10 is accessible from the left-hand side. Block off the RCV port so that no light is incident on the photodetector. Set the ADD DB switch to "-40". Connect a DMM (floating) between TP2 and TP3. Adjust R5 for a 0.00 mV ± .01 mV reading.

5.2.4.2 The next step is the adjustment of R17 (R10 on Long Wavelength Plug-In).* The exact value of the adjustment is dependent on the wavelength of the source. Therefore, one must use a known intensity source of the wavelength at which the test set will be operating. Using an NBS traceable radiometer*, measure the LED output from a small test fiber connected to the 650B XMTR port. R18 (R9 on Long Wavelength Plug-In) may be used during the initial set-up to adjust the LED output power to a convenient level if the radiometer used does not read in dBm. Loop this signal back to the 650B RCV port and adjust R17 (R10 on Long Wavelength Plug-In) for the reading obtained on the radiometer.

5.2.5 Audio Tone Adjustment

The audio board has one adjustment, potentiometer R1. With 1.0 VDC at E1, adjust R1 for 2.0 KHz ± 200 Hz at TP1.

5.3 Maintenance

Care should be taken when handling the 651B plug-in module. Do not touch the amplifier's circuitry, feedback resistors or capacitor with a finger or other possible contaminant. Should it be necessary to clean these components, clean each component with warm isopropyl alcohol. Otherwise, general maintenance should include inspection of components for good solder connections, regular battery recharging and care to keep foreign matter out of the XMTR and RCV ports of the 651B plug-in. Recharge batteries immediately after use to insure long life.

*See NOTE on previous page.

6.0 DIAGRAMS AND SCHEMATICS

List of Diagrams and Schematics

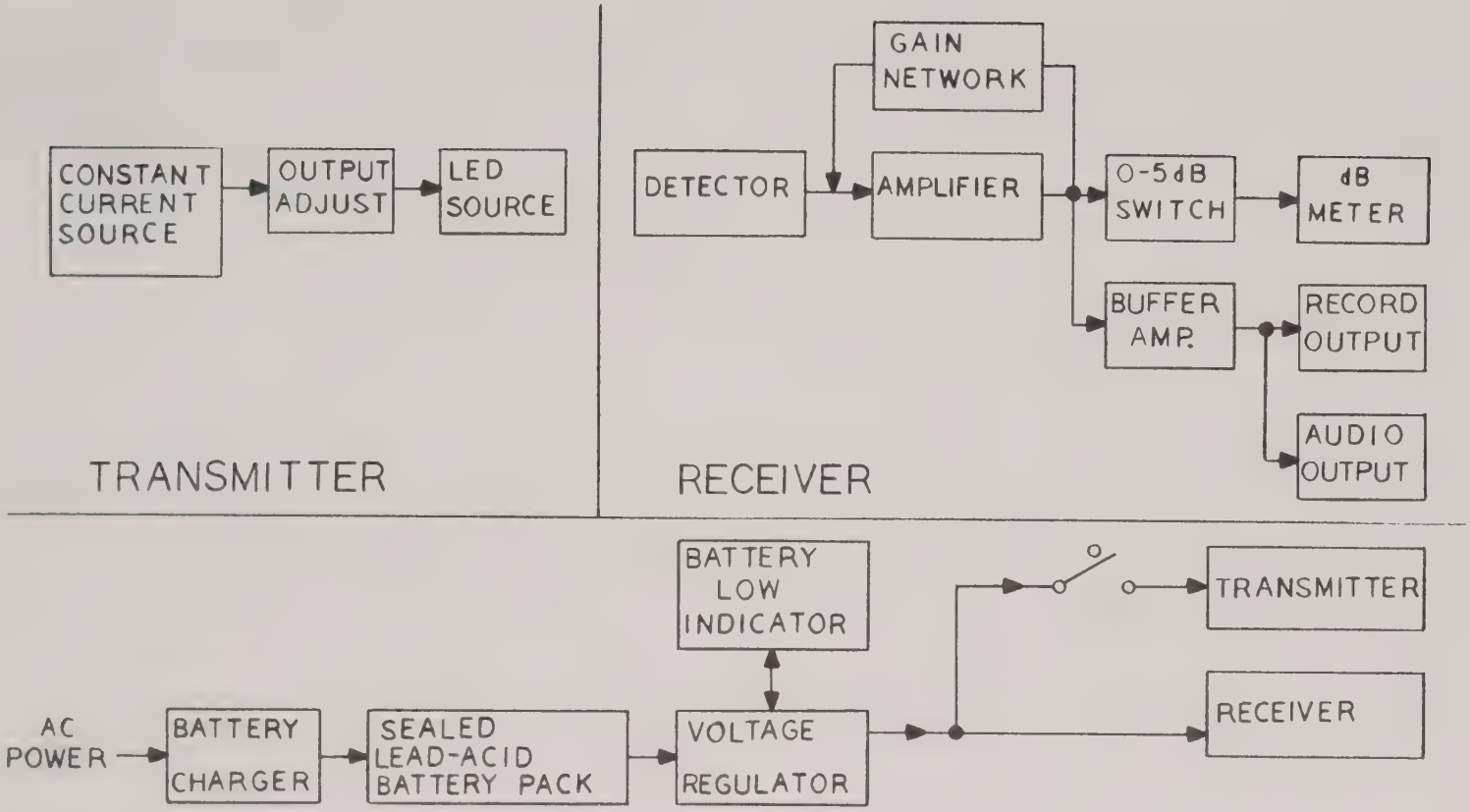
Figure 1 - 650B Block Diagram

Figure 2 - Main Board Assembly
C650B-207/D

Figure 3 - 651B and Audio Board Assemblies
C651B-207/C
C650B-208/A
C651B-217/0

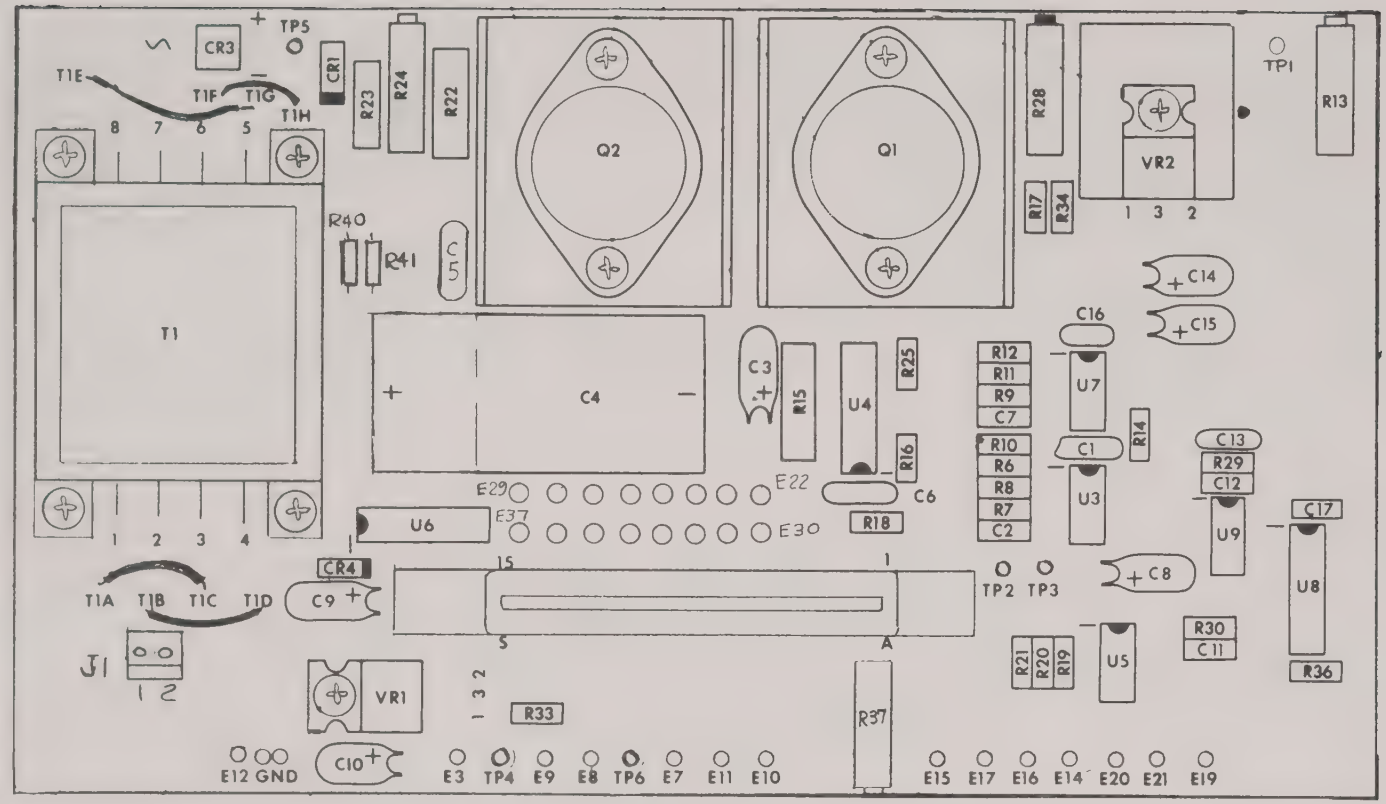
Figure 4 - Schematic - Model #651B-_ and 651B-_B
D650B-107/G

Figure 5 - Schematic - Long Wavelength Plug-In 651B-_A
C651B-117/A



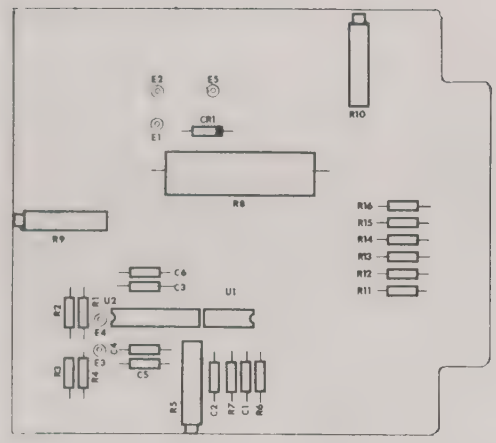
650B BLOCK DIAGRAM

FIGURE 1

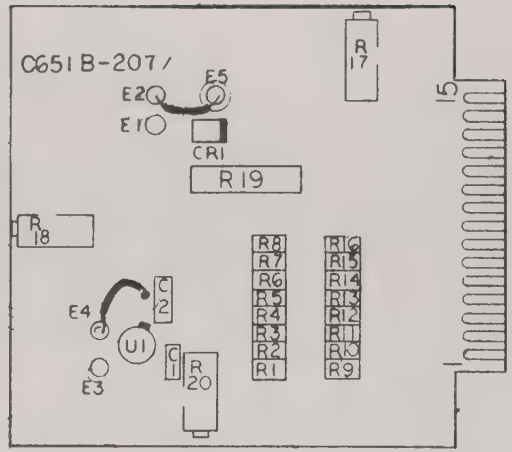


MAIN BOARD ASSEMBLY

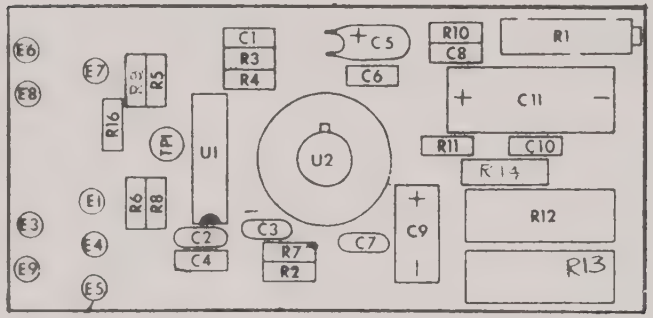
FIGURE 2



Long Wavelength Model #651B-_A

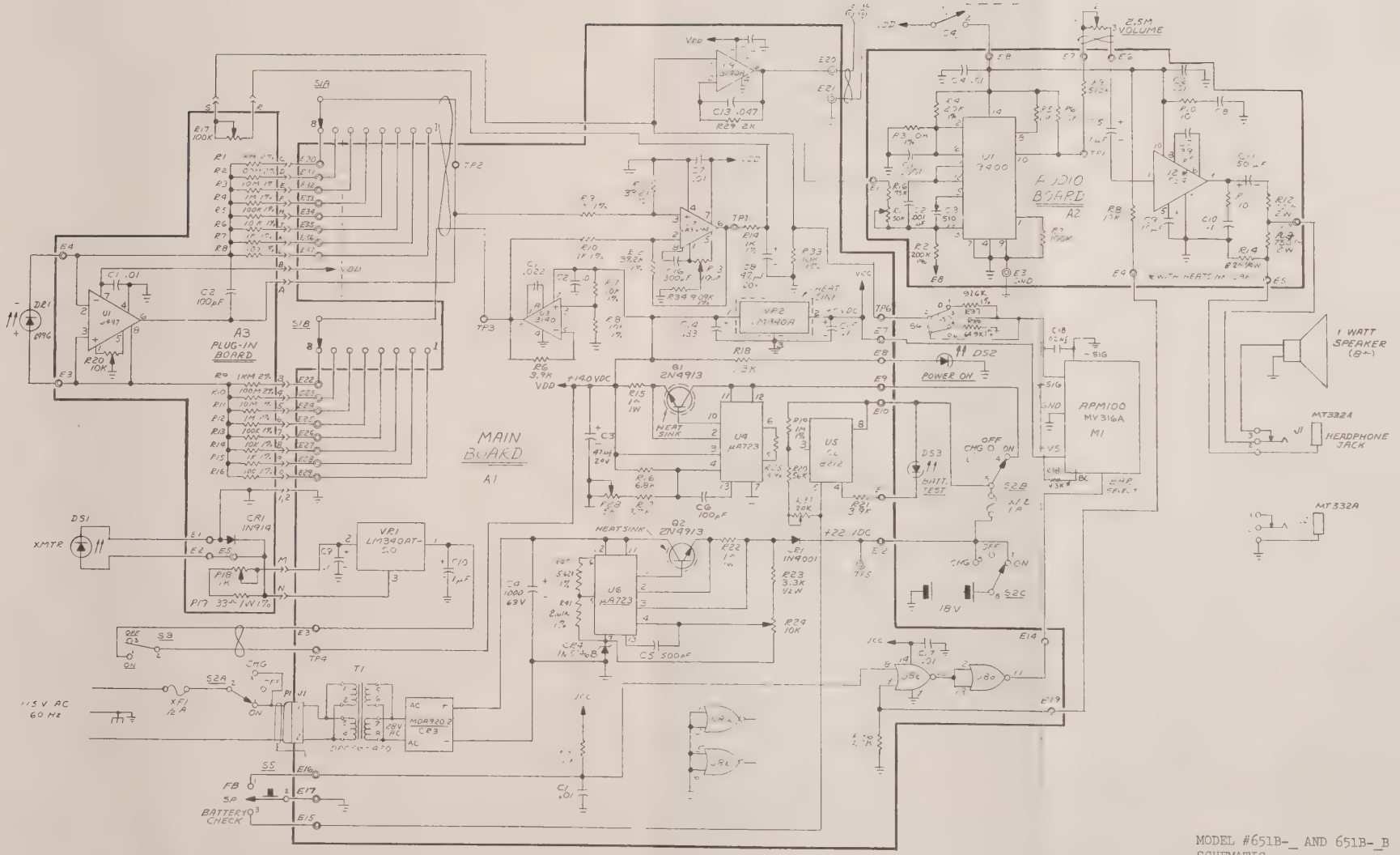


Model #651B-_ and #651B-_B



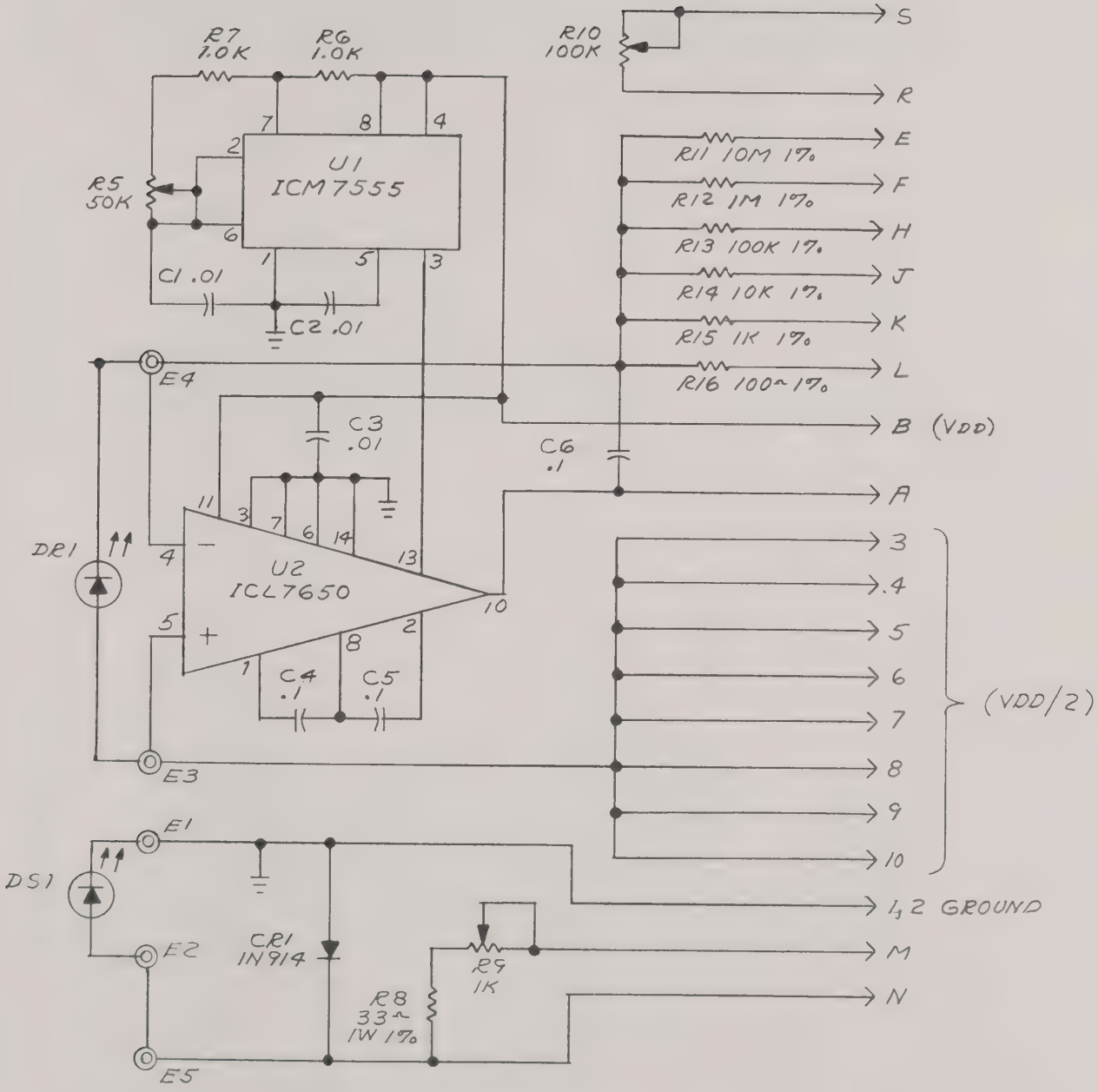
PLUG-IN AND AUDIO BOARD ASSEMBLIES

FIGURE 3



MODEL #651B-_ AND 651B-_B
SCHEMATIC

FIGURE 4



LONG WAVELENGTH PLUG-IN 651B-_A
SCHEMATIC

FIGURE 5

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
650B MAIN ASSEMBLY			
	Power Cord (Yellow)	Belden	17250
	Battery	Gates or	0810-0011 or
		G.E.	47B025CD02001
	Speaker	Quam	25A05Z8R
	Fuse	Littlefuse	313001
	Extender Board (Optional)	Bowmar	650B-215
	Fuse 3 AG 1/2A, S.B.	Littlefuse	313.500
M1	Meter	Bowmar	APM100MV316S138A
DS2, DS3	LED	Hewlett Packard	4650
	Fuseholder	Littlefuse	342-014
S1	Switch	CTS	T211
S2	Switch	C & K	7303
S3	Switch	C & K	7101
S4	Switch, Pot	Allen Bradley	73KAN048R255T
S5	Switch	C & K	7107
S6	Switch, DPDT	C & K	7201
J1, J2	Switch - Jax	Switchcraft	MT-332A
J3	Terminal, Insulated (Red)	Sealectro	016-2000-00-202
J4	Terminal, Insulated (Black)	Sealectro	016-2000-00-200
R37	Resistor, 97.6K, 1%		RN55D9762F
R38	Resistor, 4.3K, 1/4W, 5%		RC07GF432J
R39	Resistor, 64.9K, 1%		RN55D6492F
C18	Capacitor, 0.22uf	Unitrode	CGE224ZDZ
	Optical Scribe	Bowmar	651B-218
	Connector Assembly	Bowmar	651B-202
	Connector Adapter	Bowmar	651B-019
	Knob ADD DB	Control Knob	7FF2B2
	Knob AUDIO MONITOR	Control Knob	5FF1B2

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
650B MAIN P.C. BOARD			
U3	Op Amp	RCA	CA3140E
U4, 6	Voltage Regulator	National	LM723CN
U5	Voltage Det.	Intersil	ICL8212CPA
U7	Op Amp	RCA	CA3160AE
U8	Quad. Nor Gate	Motorola	MC14001BP
U9	Op Amp	RCA	CA3140AE
Q1, 2	Power Transistor	T.I.	2N4913
CR1	Diode	Motorola	1N4001
CR3	Diode Bridge	Motorola	MDA920-2
CR4	Diode, Zener 16V		1N5246B
VR1, 2	Regulator, 5 Volt	National	LM340T-5.0
C1	Capacitor, .022uf	Sprague	3CZ5U223X0050C5
C2, 7, 11, 17	Capacitor, .01uf	Unitrode	CGC103ZDZ
C3, 8	Capacitor, 47uf	Sprague	196D476X9020PE4
C4	Capacitor, 1000uf, 63V	Siemens	B41010/81006
C5	Capacitor, 500pf	CDE	CD15FD501J03
C6	Capacitor, 100pf	CDE	CD15FD101J03
C9, 15, 12	Capacitor, .1uf	Sprague	196D104X9035HA1
C10	Capacitor, 1.0uf	Sprague	196D105X9035HA1
C13	Capacitor, .047uf	Sprague	3CZ5U473X0050C5
C14	Capacitor, .33uf	Sprague	196D334X9035HA1
C16	Capacitor, 300pf	CDE	CD15FD301J02
R6, 21, 25	Resistor, 3.9K, 1/4W, 5%	Allen Bradley	CB3925
R7, 8, 33	Resistor, 10K, 1%	Allen Bradley	RN55D1002F
R9, 10, 14	Resistor, 1K, 1%	Allen Bradley	RN55D1001F
R11, 12	Resistor, 39.2K, 1%	Allen Bradley	RN55D3922F
R13	Potentiometer, 100K	Bourns	3006P-104
R15, 22	Resistor, 1 ohm, 1W	Sprague	239E1R05
R16	Resistor, 6.8K	Allen Bradley	CB6825

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
650B MAIN P.C. BOARD (Con't)			
R17, 36	Resistor, 4.7K	Allen Bradley	CB4725
R18	Resistor, 1.3K	Allen Bradley	CB1235
R19	Resistor, 1M, 1%	Allen Bradley	RN55D1004F
R20	Resistor, 56K, 1/4W, 5%	Allen Bradley	CB5635
R23	Resistor, 3.3K, 1/2W	Allen Bradley	EB3325
R24	Potentiometer, 10K	Bourns	3006P-103
R28	Potentiometer, 5K	Bourns	3006P-502
R29	Resistor, 2K	Allen Bradley	CB2025
R30	Resistor, 10K	Allen Bradley	CB1035
R34	Resistor, 9.09K, 1%	Allen Bradley	RN55D9091F
R37	Potentiometer, 20K	Bourns	3006P-203
R40	Resistor, 5.62K, 1%	Allen Bradley	RN55D5621F
R41	Resistor, 2.61K, 1%	Allen Bradley	RN55D2611F
T1	Transformer	Signal	DPC56-420
J1	Header Assembly	Amp	640388-2
650B AUDIO BOARD			
R1	Adjust Resistor, 50K, 5%	Helitrim	89WR50K
R2	Resistor, 200K, 1/10W, 1%		RN55C204F
R3	Resistor, 10K, 1/10W, 1%		RN55C103F
R4	Resistor, 20K, 1/10W, 1%		RN55C203F
R5, 6, 8	Resistor, 10K, 1/4W, 5%		RC07GF103J
R7	Resistor, 100K, 1/4W, 5%		RC07GF104J
R9	Resistor, 510K, 1/4W, 5%		RC07GF514J
R10, 11	Resistor, 10 ohm, 1/4W, 5%		RC07GF100J
R12	Resistor, 10 ohm, 2W, 5%		RC42GF100J
R13	Resistor, 750 ohm, 2W, 5%		RC4CGF751J
R14	Resistor, 8.2 ohm, 1/4W, 5%		RC07GF8R2J
R16	Resistor, 75K, 1/4W, 5%		RC07GF753J
U1	Integrated Circuit V/F Convert	Teledyne	9400CJ
U2	Integrated Circuit, 1W Amp	Motorola	MC1554G

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
650B AUDIO BOARD (Con't)			
C1, 2	Capacitor, .001uf, 20%	Unitrode	CGB102MDX
C3	Capacitor, 510pf, 500V, 5%		CM05FD511J03
C4, 6	Capacitor, .01uf,	Unitrode	CGC103ZDZ
C5	Capacitor, 1uf, 35V, Tant.	Sprague	196D105X9035HA1
C7	Capacitor, 39pf, 500V, 5%		CM04ED390J03
C8, 10	Capacitor, .1uf, 10%	Unitrode	CGE104KDX
C9	Capacitor, 10uf, 25V, Elec.	CDE	NLW 10-25
C11	Capacitor, 150uf, 25V. Elec.	CDE	NLW 150-25
	Spreader, 10 Pin for I.C.	Thermalloy	7717-21
651B MODULE (Model #651B-_, #651B-_B)			
R1, 9	Resistor, 1KM, 2%	Eltec	Model 104
R2, 10	Resistor, 100M, 2%	Eltec	Model 104
R3, 11	Resistor, 10M, 1%	Mepco/Electra	5053YL
R4, 12	Resistor, 1M, 1%	Allen Bradley	RN55D1004F
R5, 13	Resistor, 100K, 1%	Allen Bradley	RN55D1003F
R6, 14	Resistor, 10K, 1%	Allen Bradley	RN55D1002F
R7, 15	Resistor, 1K, 1%	Allen Bradley	RN55D1001F
R8, 16	Resistor, 100 ohm, 1%	Allen Bradley	RN55D1000F
R17	Potentiometer, 100K ohm	Bourns	3006P-104
R18	Potentiometer, 1K ohm	Bourns	3006P-102
R19	Resistor, 33 ohm, 1W	Dale	MFF-1T-133 1%
R20	Potentiometer, 10K ohm	Bourns	3006P-103
C1	Capacitor, .01uf	Unitrode	CGC103ZDZ
C2	Capacitor, 100pf	CDE	CD10FD101J03
CR1	Diode	Motorola	1N914
U1	Op Amp	Bowmar	6497
	Photodiode	Bowmar	6496
	LED (651B-_)	Bowmar	B6506-1
	LED (651B-_B)	Bowmar	B6506-2

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	PART NUMBER
651B MODULE (Long Wavelength Model #651B-_A)			
R5	Resistor, Variable, 50K	Bourns	3006P-503
R7, 15, 6	Resistor, 1K, 1%		RN55D1001F
R8	Resistor, 33 ohm, 1W, 1%	Dale	MFF-1T-133
R9	Resistor, Variable, 1K	Bourns	3006P-102
R10	Resistor, Variable, 100K	Bourns	3006P-104
R11	Resistor, 10M, 1%	Mepco/Electra	5053YL
R12	Resistor, 1M, 1%		RN55D1004F
R13	Resistor, 100K, 1%		RN55D1003F
R14	Resistor, 10K, 1%		RN55D1002F
R16	Resistor, 100 ohm, 1%		RN55D1000F
C1, 2, 3	Capacitor, .01uf	Unitrode	CGC103ZDZ
C4, 5, 6	Capacitor, .1uf, 10%	Unitrode	CGE104KDX
CR1	Diode		1N914
U1	Integrated Circuit		ICM7555
U2	Integrated Circuit	Bowmar	B6538

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